The ecological restoration of Otamahua/Quail Island 3. Problem plants and their control

Colin J. Burrows[1] and John K. Watson[2]

[1]Department of Plant and Microbial Sciences, University of Canterbury
Private Bag 4800, Christchurch, New Zealand

[2]11A Te Papau Crescent, Diamond Harbour, Banks Peninsula, New Zealand

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Abstract

Among the obstacles to the successful planting of native woodland on the island is a dense cover of introduced turf-forming grasses on the planting sites. They are strong competitors for water with planted trees and shrubs. Other problems foreseen for the planted native woodland are from increase of introduced woody species, including pines, cypresses, oaks, ashes, eucalypts, silver poplars and shrubs, (mainly gorse, broom, flowering currant, brier rose, elderberry, hawthorn, boxthorn and boneseed). Thistles and some other forbs also create difficulties for the project. Another class of problems related to public recreational use of the island arises from the presence of some plant species with poisonous properties, and others which cause nuisance to people.

The weedy properties of the recognised problem plants, and control strategies for them are listed. Turf grasses are being cleared from planting sites with herbicide. The planting strategy aims for subsequent suppression of herbaceous sward plants by quick development of a canopy of the native trees and shrubs, but mulching, with weedmat, newspaper and old carpet also is being done.

Near the planting areas control of the woody problem plants (trees, shrubs and vines) is by hand-pulling, or grubbing juveniles and cutting adults. Weedy shrubs are being controlled all over the island in the same way. Where regrowth by sprouting would occur, the cut stumps are painted with herbicide. Gorse and broom control is by application of a residual herbicide. The aim with the shrub weeds is to kill all adults to prevent further seed production and dispersal. Some poisonous plants are also being controlled. For several others and the nuisance plants the appropriate measures are warnings about their toxicity or undesirable properties.

A programme and timetable is presented for eradication from the whole island of the problem shrubs and some toxic plants and for local control of some other problem herbaceous or woody plants. Attention is drawn to the need to prevent plant pests not already on the island from reaching it.

Keywords: introduced plants - problem plants - turf grasses - trees – shrubs - planted native woodland - toxic plants – nuisance plants - pest plant interception

Introduction

The initial goal of the ecological restoration project for Otamahua (Genet & Burrows 1998, 1999) is to develop extensive areas of native woodland vegetation resembling the original plant cover of the island before its deforestation, during the Maori occupation of the region (Ward 1851, Genet 1997, Wilson 1999). In preparation for the establishment of this native woodland it might be thought appropriate to completely remove the foreign plants which inhabit much of the island (Wilson *et al.* 1999). However, as noted below, it is neither practicable, nor desirable for an entirely xenophobic attitude to introduced plants to prevail. Total removal of the introduced plant cover would require huge amounts of effort and expenditure. Very destructive methods, including widespread herbicide spraying, would be necessary and this would kill native plants as well. Often they are closely associated with the foreign plants. There would be regrowth of many of the foreign species from seed stores in the soil so efforts to remove them would have to continue indefinitely. Various native animals would also be harmed by a "scorched earth" policy towards foreign plants.

A more realistic approach to dealing with introduced plant cover on Otamahua is to aim to remove only as much of it as is absolutely necessary to facilitate: 1) The initial establishment of woodland plants; 2) The future integrity of the planted woodlands; 3) The safety of visitors to the island. To some degree a virtue can be made of necessity. In many places introduced trees can provide shelter for the newly-planted native woodland. Also the dense cover of grassland on top of the island can serve as a buffer, preventing increase of other kinds of invasive weedy species.

This account identifies the introduced (and some native) species which are likely to be obstacles to the establishment, or future development of the planted native woodland, or to be dangerous to, or a nuisance to, people visiting the island. Features of the plants contributing to their problem status are also identified and specific control procedures and management strategies for these plants are outlined.

Consideration is given to the prevention of the entry of new foreign plants to the island and the mitigation of effects of such immigration. Nomenclature for plant species listed here follows Allan (1961), Healy & Edgar (1980), Connor & Edgar (1987), and Webb *et al.* (1988).

An important factor influencing decisions about the fate of introduced plant species on Otamahua, either on the planting sites, or generally, is the island's de facto status as a multi-purpose reserve, with recreation a main function, and protection of historic associations also important (cf. Genet & Burrows 1998; Ian Hill, pers. comm.). In this latter context most of the planted foreign woodland and some areas of introduced grassland are to remain because they are historic artefacts. Nevertheless, the preservation and enhancement of indigenous natural values will be the main focus in planning for the future of the ecological restoration project (cf. Genet & Burrows 1999). The present article is written in the light of experience gained during three summers of plant pest control. Much has been achieved in this time towards cutting off the supply of seeds from shrubby plant pest species, and removing young wilding trees from actual or potential planting areas for native woodland. Control of some of the toxic plants and a few casual weed species has also been done.

Appendix 1 lists additions to the flora of Otamahua since 1999 (cf. Burrows *et al.* 1999); discusses some points about seedlings of native woody plants; and provides information on additional distributions of some unwanted species. The total known vascular plant flora of the island now numbers 375 species.

Some terminology

Terms used in this article for plants with various kinds of status are explained here.

indigenous: native to specific places, usually New Zealand, or to Otamahua; the term implies long residence of a lineage of a plant species, unrelated to human introductions.

introduced: species foreign to the New Zealand flora that were brought to Otamahua, deliberately or accidentally; also referring to some species indigenous to New Zealand, but not to Banks Peninsula, that have been planted on Otamahua, and to some species brought to New Zealand, but which have spread to Otamahua from adjacent mainland sites by natural means.

native: synonymous with indigenous (q.v.).

naturalized: referring to foreign species which were originally brought to Otamahua deliberately, or reached it by accident, or naturally, and have reproduced and spread there of their own accord.

planted: deliberately established on Otamahua; this applies to many foreign pasture plants, trees, shrubs and decorative herbs, as well as some native woody species known to have been planted on the island, including a few native New Zealand species that are not indigenous in Canterbury. Many of these have become naturalized (q.v.).

pest: plants on Otamahua that are formally classified in Anon. (1998a) (the Canterbury Regional Pest Management Strategy) in the categories **containment** (*Clematis vitalba*, *Cytisus scoparius*, *Ulex europaeus*) or **surveillance** (*Berberis glaucocarpa*, *Buddleja davidii*, *Chrysanthemoides monilifera*, *Conium maculatum*, *Crataegus monogyna*, *Lycium ferocissimum*, *Rosa rubiginosa*, *Silybum marianum*). (N.B. see Table 1 for common names of the cited plants).

problem: plant species that cause difficulties for humans in various contexts - in this case for the ecological restoration of Otamahua, or for various other activities that occur on the island.

weed: unwanted plant species with properties of regeneration or resilience of growth which enables it to resist control measures.

wild: plants increasing in population size and growing naturally, without human effort to maintain them (approximately synonymous with naturalized (q.v.)).

The main problem plants of Otamahua and their control

Turf-forming grasses and forbs

The predominant plant cover on the planting sites for native woodland (and over more than half of the island's surface) (Burrows *et al.* 1999) is dense, turfy grassland, with associated dicotyledon herbs (forbs). The grasses, all introduced, are mainly rhizomatous species, most of which also seed freely and maintain stores of seeds in the soil (Table 1). Some of the forbs are also rhizomatous or stoloniferous and also regenerate from stored seed populations.

Although no records appear to have been kept, it is assumed that most of the grasses (noted in Table 1) and some associated dicotyledon herbs were deliberately planted in pasture seed mixtures, sown in worked paddocks during the main periods of sheep-farming on the island, 1887-1949 and 1958-1985 (Jackson 1990). Many other herbaceous plants, including grasses, were apparently accidentally introduced in a variety of ways, from 1851 onwards (cf. Burrows et al. 1999). The most likely means for accidental introductions of seeds of the casual weedy species were: as contaminants of pasture seed mixtures; on the coats or in the guts of stock being brought to the island; on the clothing or footwear of human visitors; in straw, hay or soil brought to the island; on machinery used temporarily on the island. One probable example of a relatively recent grass introduction, almost certainly spread by machinery, is *Phalaris aquatica*, noted in Burrows et al. (1999).

Some weedy herbaceous species, especially members of Asteraceae such as *Carduus tenuiflorus*, *Cirsium arvense*, *C. vulgare*, *Silybum marianum* and *Taraxacum officinale* could have reached the island, originally, by aerial transport

Table 1 Occurrence, reproductive features and proposed control for potential problem plants on Otamahua/Quail Island

*Refers to situation in 1998; P = perennial, B = biennial, ∇ = only in planting areas.

Introduced species	Distribution/relative abundance of naturalised individuals*	Probable origin on island	Natural propagation/ lifespan	Seed dispersal mode	Seed bank size/duration (in soil)	Complete removal achievable	Control strategy	Control methods
A. Herbs i Grasses								
Agrostis capillaris browntop	widespr./v. abund.	planted pasture	seed, rhizome/P	wind, clothing, shoes	over winter	no	local kill, suppress with tree growth	herbicide, close planting of trees
Arrhenatherum elatius tall oat grass	localized /locally common	planted pasture	seed, short rhizome/P	wind, clothing	v. short term	no	local kill, suppress with tree growth	herbicide, close planting of trees
Dactylis glomerata cocksfoot	widespr./v. abund.	planted pasture	seed/P	wind, clothing	over winter	no	local kill, suppress with tree growth	herbicide, close planting of trees
Elytrigia repens old man twitch	localized/locally common	accidental, farm activity	rhizome/P	rarely ever seeds	small, persistent	no	local kill, suppress with tree growth	herbicide, close planting of trees
Festuca rubra chewings fescue	localized/abund.	planted pasture	seed, rhizome/P	wind, clothing	v. short term	no	local kill, suppress with tree growth	herbicide, close planting of trees
Holcus lanatus yorkshire fog	widespr./abund.	planted pasture	seed, short rhizome/P	wind, clothing	large, persistent	no	local kill, suppress with tree growth	herbicide, close planting of trees
Lolium perenne perennial ryegrass	widespr./abund.	planted pasture	seed, short rhizome/P	wind, clothing	over winter, small, persistent	no	local kill, suppress with tree growth	herbicide, close planting of trees
Phalaris aquatica big canary grass	localized mainly near stock dam, farm buildings/locally common	accidental, track and dam construction	seed, swollen tubers/P	wind	unknown	probably	kill out all colonies	herbicide
Poa pratensis field poa	localized/abund.	planted pasture	seed, rhizome/P	wind, clothing, shoes	over winter, small, persistent	no	local kill, suppress with tree growth	herbicide, close planting of trees

ii. Dicotyledons								
Carduus tenuiflorus winged thistle	scattered colonies/locally common	possibly oversea, or accidental, farm activity	wind			possibly	kill out all colonies	herbicide, avoid ground disturbance, biocontrol (insect)
Conium maculatum hemlock	local colonies/limited numbers	accidental, sewage treatment construction	seed/B	? wind	over winter, small, persistent	yes	kill out local colonies	herbicide, pull grub, avoid ground disturbance
Conyza spp. fleabane	scattered colonies	oversea	seed/B	wind	unknown	possibly	kill out all colonies	hand pull
Cirsium arvense california thistle	local colonies/comm-on	possibly oversea, or accidental, farm activity	seed, rhizome/P	wind	over winter, small, persistent	no	kill out local colonies	herbicide, cut
Cirsium vulgare scots thistle	widespread/co-mmon	possibly oversea, or accidental, farm activity	seed/B	wind	large, short term	no	kill out local colonies	herbicide, grub
Digitalis purpurea foxglove	scattered colonies/few	accidental, farm activity	seed/B	? wind	small, persistent	yes	kill out all colonies	hand pull
Silybum marianum variegated thistle	scattered colonies locally common	possibly oversea, or accidental, farm activity	seed/B	wind	unknown	possibly	kill out all colonies	herbicide, avoid ground disturbance
iii. Fern								
Dryopteris filix-mas male fern	scattered colonies	oversea	spores/P	wind	unkown	yes	kill out all colonies	grub

Introduced species	Distribution/relative abundance of naturalised individuals*	Probable origin on island	Natural propagation/ lifespan	Seed dispersal mode	Seed bank size/duration (in soil)	Complete removal achievable	Control strategy	Control methods
B. Woody plants								
i. Shrubs								
Chrysanthemoides monilifera boneseed	localized/very abundant	planted, decorative	seed/P	bird	large, persistent	probably	kill seed source, remove juveniles	pull/grub small plants, cut adults, herbicide on stump
Crataegus monogyna hawthorn	scattered/mod. common	planted, shelter, decorative	seed/P	bird	small, short-term	yes	kill seed source, remove juveniles	pull/grub small plants, cut adults, herbicide on stump
Cytisus scoparius broom	localized/common	planted, stock fences	seed/P	projected	large, persistent	possibly	kill seed source, remove juveniles, suppress seed bank	pull/grub small plants, cut adults, herbicide on stump, plant sites densely with *Kunzea*
Lycium ferocissimum boxthorn	localized/locally common	planted, shelter	seed/P	bird	unknown	yes	kill seed source, remove juveniles	pull/grub small plants, cut adults, herbicide on stump
Ribes sanguineum red flowering currant	scattered/locally very abundant	planted, decorative	seed/P	bird	large, short-term	yes	kill seed source, remove juveniles	pull/grub, cut, herbicide on stump
Rosa rubiginosa sweet briar	scattered/few	planted, decorative	seed, rhizome/P	bird	small, short-term	yes	kill seed source, remove juveniles	grub and herbicide
Sambucus nigra elderberry	scattered/mod. common	planted, decorative, shelter	seed/P	bird	over winter	yes	kill seed source, remove juveniles	pull/grub small plants, cut adults, herbicide on stump
Ulex europaeus	localized/locally common	planted, stock fences	seed/P	projected	large, persistent	possibly	kill seed source, remove juveniles, suppress seed bank	herbicide, plant sites densely with *Kunzea*
ii. Vine								
Solanum dulcumara bittersweet	localized/few	planted, decorative	seed/P	bird	over winter	yes	remove all plants encountered	hand-pull

iii. Trees								
Betula pendula silver birch	localized/few	planted, decorative	seed/P	wind	over winter	yes∇	remove juveniles	pull, grub
Cupressus macrocarpa monterey cypress	plantations/common	planted, shelter, wood	seed/P	wind	unknown	yes∇	remove juveniles	cut, pull, grub
Eucalyptus globulus blue gum	localized/few	planted, shelter, wood	seed/P	wind	very short term, few persistent	yes∇	remove juveniles	pull, grub, cut, herbicide on stump
Fraxinus excelsior ash	localized	planted, decorative	seed/P	wind	short term, some persistent	yes∇	remove juveniles and some adults	herbicide on juveniles, cut adults and herbicide on stump
Ilex aquifolium holly	very local	planted, decorative	seed/P	bird	over winter	yes	remove all plants	cut, herbicide on stump
Pinus radiata monterey pine	plantations/common	planted, shelter, wood	seed/P	wind	large, persistent on tree, small, persistent in soil	yes∇	remove juveniles	cut, pull, grub
Prunus avium bird cherry	very local	planted, decorative	root suckers, seed/P	bird	small, persistent	yes	remove adult, juveniles	herbicide on juveniles, cut adult and herbicide on stump
Populus alba var. *nivea* silver poplar	localized patches	planted, decorative	root suckers/P		no viable seeds	yes	remove adults, juveniles locally	herbicide injection and on cut stump
Quercus ilex holm oak	localized patches	planted, shelter, decorative	seed/P	gravity	unknown	yes∇	remove juveniles	pull, grub, cut, herbicide on stump
Quercus robur european oak	one large and some smaller patches, individuals	planted, shelter	seed/P	gravity	over winter	yes∇	remove juveniles	pull, grub, cut, herbicide on stump

of their achenes. Other means by which foreign plants could have reached Otamahua are considered by Burrows et al. (1999).

Turfy grass cover is a hindrance to natural establishment of native trees and shrubs in the western Banks Peninsula region (cf. Anon. 1994). It creates a two-fold problem when planting of trees and shrubs is attempted (cf. Anon. 1980, Porteous 1993, Stephen Brailsford, pers. comm.). Firstly, the clearance of the sites for planting is difficult. Secondly there are strong competitive influences from the grasses. Rhizomatous grasses can grow back into the cleared area after planting. Also, if the grasses maintain seed banks they can reestablish in the disturbed soil, through germination of those seeds.

Competition by the turf grasses with planted woody species could be for light and nutrients, but in the Otamahua context the main competitive effect is the efficient sequestration of water by the grasses. Their foliage intercepts precipitation and also, the dense mat of roots and rhizomes near the soil surface abstracts water before it can reach the roots of woody plants. These effects are most critical in summer when rainfall is at a minimum and evapotranspiration at its peak. If individual precipitation events are small almost all of the water reaching the sward may be evaporated from the grass canopy. If the soil surface is bare, or covered by a mulch, at least some of the water from precipitation will penetrate the soil. Further details relevant to these points are considered in Leckie & Burrows (2001).

The most practical means for dealing with a turfy grass cover (containing *Agrostis capillaris, Arrhenatherum elatius, Dactylis glomerata, Festuca rubra, Poa pratensis* etc), before planting trees and shrubs, is to kill it on the planting sites with herbicides such as Glyphosate (a general plant-killer) or Gallant (a grass-killer). Details of the practices for planting and post-planting treatments are outlined elsewhere (Leckie & Burrows, 2001). The desirable initial action is to remove the grass influence on areas of at least a square metre for each tree or shrub to be planted, and to continue to remove the grass regrowth with grass-specific herbicide, should this be necessary. The adjunct strategies are to: 1) Plant the trees and shrubs relatively densely; 2) Provide conditions (nutrients, moisture) which will enable the plants to grow quickly to form bushy canopies that will suppress the competing herbaceous plants; 3) Place some sort of mulch around the base of the newly-inserted plants, mainly to conserve moisture. Dead foliage of the killed grass, weed mat, wads of newspaper or old carpet are appropriate for this purpose.

The tall, perennial, clump-forming grass *Phalaris aquatica* is spreading on the island and could cause difficulties for the restoration project. Its complete eradication, using Glyphosate, is recommended.

Perennial herbaceous plants such as the forbs *Acaena novae-zelandiae, Cirsium arvense* or *Rumex obtusifolius* and some annuals or biennials (e.g., *Cirsium vulgare, Galium aparine, Vicia sativa)* can also cause competitive problems for planted trees and shrubs. They increase on freshly-disturbed soil. Pre-planting treatment with a herbicide such as Glyphosate can be used to remove them from the general area, as far as possible.

Acaena novae-zelandiae is a native species which should not be killed out indiscriminately. Two tall native forbs, *Senecio glomeratus* and *S. minimus* appear densely on some planted sites, but they are only weak competitors. No action is needed to clear them except immediately beside planted trees or shrubs. *S. glomeratus* is the main host plant for the native magpie moth, *Nyctemera annulata,* and is worth fostering for this reason. Hand clearance is the usual post-planting treatment for clearing the dicotyledonous weeds though judicious use of a weed-eater is possible on some sites.

The most troublesome herbaceous species invasive on planted areas on Otamahua, other than rhizomatous grasses already mentioned, have proved to be scots thistle *Cirsium vulgare*

and californian thistle, *C. arvense.* The former, a biennial, needs disturbed ground on which to establish. It is entirely reliant on seeds for its regeneration and large soil stores of the wind-dispersed "seeds", (actually fruits) may develop, but they are viable for only 1-2 years. The plant is most vulnerable at the rosette, or young flower stem stage, when grubbing or cutting of the whole rosette is usually fatal.

Cirsium arvense is a summer-green perennial with a deep network of underground roots. It forms male or female clones by vegetative spread, after initial seedling establishment. If broken into pieces the roots can give rise to many new plants. Wind-dispersed "seeds" from the female clones may form small, but long-lasting stores in the soil.

During the summers of 1998-99 and 1999-2000 *C. arvense* came up densely in some newly-planted areas on Otamahua. In the second and third years the 1998-99 patches were not as dense as in the first. However much tedious work was required to hand-release affected young trees. As no biocontrol agents suitable for use on the island are available at present for this species (Fowler 1999; Anon. 2000) a two-phase control effort is being made on *C. arvense*-rich areas before any planting occurs. It requires the weed to be sprayed with Glyphosate twice in the same year.

Some other herbaceous perennial or biennial herbs of the genera *Carduus, Cirsium* and *Silybum* with wind-dispersed "seeds" (Table 1) might invade the planted areas from distant locations. As a precaution dense infestations of any of these species adjacent to planting sites could be controlled with Glyphosate prior or subsequent to planting. Once a woodland canopy becomes established at a metre or more above the ground these herbs are not likely to cause further difficulty for the restoration project.

Woody species

Invasion and competition by certain introduced tree and shrub species (Table 1) could be troublesome for the woodland plantings. All of those which are most likely to cause such difficulties are thought to have been planted originally for shelter, or amenity. They have, in most cases, spread far beyond their original nucleus areas (Fig. 1) (Burrows *et al.* 1999). In the last two years considerable efforts have been made by Trust and Department of Conservation work parties to control these species. This follows on from similar efforts in the previous two decades by Department of Conservation staff (John Trotter, Murray Lane, Claire Findlay, John Watson).

The fast-growing tree species *Pinus radiata* and *Cupressus macrocarpa* have wind-dispersed seeds that spread from their parents over relatively short distances (a few tens of metres up to, possibly, about a hundred metres). Once established their great potential height, as well as their rapid growth rates, make them strong competitors with native woodland species. Some other trees, all angiosperms, with wind-, or gravity-dispersed seeds, (particularly *Betula pendula, Eucalyptus globulus, Fraxinus excelsior, Quercus ilex* and *Q. robur*) and one which reproduces on the island by root suckering, *Populus alba,* could also be invasive (Table 1). Of these *Fraxinus* shows the greatest propensity for spread (over distances up to 400 m).

The shrubs *Cytisus scoparius* and *Ulex europaeus* have projectile seeds which disperse only a metre or two away from the parents (but over longer distances by rolling downhill). Complete eradication of these two species is recommended, but will be a very long-term task as the hard-coated seeds persist in the soil for decades.

The most pernicious woody problem plants on the island are fleshy-fruited species whose seeds are spread by birds into wooded areas all over the island (Table 1). Those of most concern are *Chrysanthemoides monilifera, Crataegus monogyna, Lycium ferocissimum, Ribes sanguineum, Rosa rubiginosa* and *Sambucus nigra.* Blackbirds, starlings and silvereyes are the main

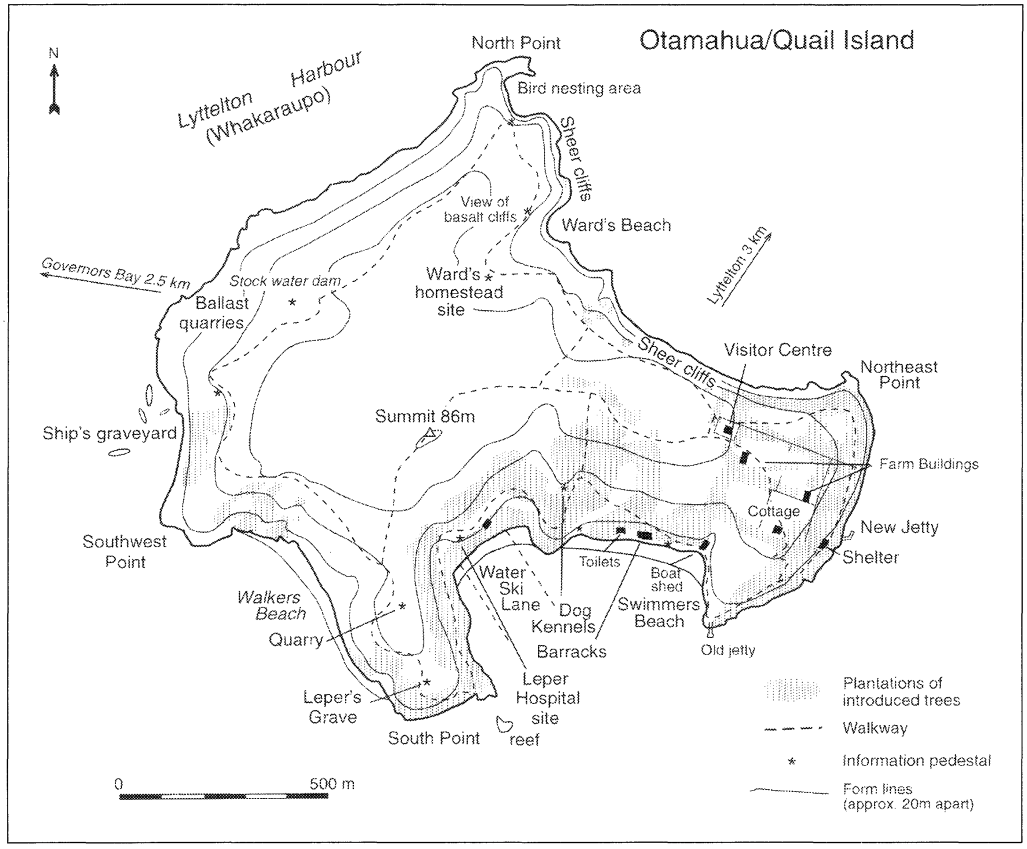

Figure 1 Location map

dispersal vectors. Seeds are carried distances ranging from a few tens of metres up to a few hundred metres. Total removal of these shrub species from the island is desirable. Again, there are problems of regrowth from seeds stored in the soil, though for some species seeds remain viable for short periods (one or two years) only (Table 1).

Two native species, the vines *Muehlenbeckia australis* and *M. complexa*, and the hybrid between them, also spread by birds, may cause problems in planted woodlands as their vigorous growth can smother other, more desirable, shrubs and young trees. Local control of them may be necessary.

Where adult *Pinus radiata* and *Cupressus macrocarpa* occur so close to planting areas (or to other patches of native vegetation) that their seeds could fall within them, the trees are felled (in some cases after first ring-barking them). All seedlings and saplings of these species are cleared away, by hand-pulling or cutting, within a 250 m radius of each planting area or each significant area of native vegetation. Similar treatment is accorded, during the growing season, to young *Betula pendula, Eucalyptus globulus, Fraxinus excelsior* and the *Quercus* spp.. Actively growing *Populus alba* adults and saplings are cut and the

stumps painted with Tordon or Escort herbicide; smaller sprouts are sprayed with Glyphosate.

Effort has been focussed, in the last two years, on complete clearance of adults of the shrubby weeds over the whole island. This has largely been accomplished, although some patches of *Chrysanthemoides, Lycium* and *Ribes* remain to be dealt with. Areas up to 250 m from the perimeter margin of each planting area are also searched, carefully, for juveniles of any problem shrubs. They are removed by hand-pulling, or grubbing (or cutting and painting with herbicide, if necessary). Some more extensive searches to remove juveniles of the shrub weeds have also been done and comprehensive coverage of the island in this way (except the northern and northeastern cliffs) has been done in late 2000-early 2001. Control of the shrub weeds is done during the growing season, preferably before fruit are ripe: for boneseed and boxthorn Oct.-Nov.; for the remainder Oct.-Dec.

Control of *Crataegus*, *Rosa* and *Sambucus* (and *Muehlenbeckia* vines, should this be necessary) is by sawing adults off near the base, and immediately painting the stumps with Escort or Tordon herbicide. *Ribes sanguineum* is usually pulled or grubbed out, but grubbing is kept to a minimum to avoid stirring up weed seeds in the soil and the baring of soil (which facilitates germination of seeds of various weeds and the establishment of the resulting seedlings). This species has been one of the more difficult shrubs to remove from the island because of its tolerance of some shade, and the regrowth of the population from the large, seed bank. However the currant population is now much diminished.

Ulex europaeus and *Cytisus scoparius* are difficult to control. A battery of biocontrol agents is available for each of these species (Harman *et al.* 1996, Anon. 1998b), but the Otamahua adult populations are small and dispersed. The organisms probably would not be effective against them. Adult *Ulex* and *Cytisus* are killed with Tordon Brushkiller (John Trotter, pers. comm.), or Glyphosate. In some sites where these two weeds are adjacent to native vegetation they are sawed off and the stumps painted with Escort, or Tordon. As Tordon is a residual herbicide, lasting 1-2 years in the soil especially in dry conditions, it cannot be sprayed where planting of native woodland is contemplated within that time (Fussell & Walton 1995). However it has the advantage that seedlings emerging one to two years after the initial spraying can be killed.

Other practices are possible where seed banks of gorse and broom are present. One is to leave those areas free from disturbance or planting, encourage growth of a dense grass sward, and continue to remove young plants as they emerge. Regrowth of young plants can be hand-pulled when small, or sprayed with Escort, or Tordon. Another approach might be to plant the areas densely with *Kunzea ericoides*, aiming to suppress the regrowth of the weeds, but this has not been tried so far.

All of the woody plants considered so far (except a few gorse and broom patches on cliffs) are generally accessible, and their populations small enough to be dealt with using the recommended practices, with a good likelihood of removal of all adults and most juveniles in 2001. Regular annual monitoring will be needed thereafter, for a few years, to identify and remove new seedlings and saplings.

Chrysanthemoides monilifera, is a special case. In 1998 it occurred abundantly at the base of the northeastern cliffs of Otamahua, distant from the proposed native woodland planting areas. It was, at the time, the most abundant weedy shrub on the island. It flowers prolifically, and has fleshy fruit and seeds that are dispersed by birds. It maintains large seed stores in and on the soil and a proportion of the seeds is thought to retain viability for ten years when stored in the soil (Table 1). Juveniles may flower and produce seeds in their first or second year. Young plants are easily pulled out, and susceptible to Glyphosate, but the adults have to be cut off and painted with Escort or Tordon. By now all

relatively easily accessible adult plants have been killed, but some remain on high, inaccessible ledges and in crevices on the cliffs. An effort is to be made to clear the remaining adults of this species from all sites on the island over the next two years. Complete removal of the species from the island may take another decade because of the longevity of stored seeds. A bonus has been the destruction of many seeds by mice, present in large numbers in summer 2000 - 2001.

Lycium ferocissimum also occurs in some inaccessible locations, including sheer cliffs near the northern tip of the island. Its adult population is relatively small, but its thorniness makes it a formidable adversary. Again, an effort is to be made to clear all adults over the next two years.

After the good progress made to date on weed clearance (entailing major physical effort, but relatively low costs because of the voluntary labour) the difficult task ahead will be to sustain the effort. This will require annual surveillance, virtually of the whole island, and follow-up control work. Some efforts to clear weeds on the difficult cliff-face sites have already been made, by workers suspended on ropes, and more of this will be needed.

Benefits of the turf grassland cover

The dense grass sward covering the summit of Otamahua can, in the meantime, be seen to be a major benefit, as a buffer to prevent easy establishment of shrubs such as boneseed, elderberry, hawthorn, boxthorn and red-flowering currant over wider areas on the island. As far as possible, to maintain this buffer zone, no disturbance should occur in this area, until restoration planting is to be done.

Toxic and nuisance plants

Some of the plants on Otamahua, both native and introduced, have toxic properties. Poisoning of stock and in some cases humans, is reported for these species (Connor 1977). Table 2 lists the species known to (or suspected to) have caused severe illness or death of stock or people. Many other species, not listed, have been recorded as having poisoned stock when relatively large amounts of foliage were consumed (e.g., the woody plants *Sambucus nigra*, *Cupressus macrocarpa*; the herbs *Narcissus* spp., *Phalaris aquatica*, *Trifolium repens*, *Ranunculus* spp., *Rumex acetosella*; the ferns *Cheilanthes humilis* and *Pteridium esculentum*) (Connor 1997). It seems unlikely that anyone would swallow enough of any of these to harm themselves. The same might seem to apply to most species listed in Table 2, especially as they are bitter or otherwise unpleasant to the taste. However, they are also highly toxic and ingestion of relatively small amounts could cause death. *Urtica ferox* is a special case; it has its own warning system, but prolonged contact with it can be very dangerous.

The most practicable way of dealing with the threat to members of the public from the toxic plants on the island is to foster awareness. Information could be made available near the jetty or at the information centre on the island. Parents or care-givers should be encouraged to warn children about the dangers of eating plants (especially their fruit, green or ripe). This particularly applies to *Corynocarpus laevigatus*, *Solanum dulcumara, S. laciniatum* and *Quercus robur.*

Most of the introduced toxic plants could be totally removed from the island, but for all but a few this is not envisaged, for various reasons. For species such as *Conium maculatum*, and *Digitalis purpurea*, for which it can be recommended without qualms, it will take some time, as they regenerate from soil seed stores. Annual efforts to remove adults before they set seeds have been effective.

Other plants on Otamahua have adherent fruits or prickly shoot systems, or stinging hairs (*Urtica urens*) and cause nuisance (Table 3). The native *Acaena novae-zelandiae* and *Discaria toumatou* are relatively abundant but can usually

be avoided. Each of the introduced prickly woody plants on the island is already scheduled for eradication (Table 1). The biennial prickly herbs *Carduus tenuiflorum, Cirsium arvense, C. vulgare* and *Silybum marianum* can be controlled, as necessary, manually, or with herbicide (Table 1). Use of biocontrol agents should be investigated, also (cf. Harman *et al.* 1996; Anon. 1998b). The *Bromus* spp. are too abundant to eliminate entirely, but they can be suppressed in some places (e.g. near the Visitor Centre) by appropriate woodland planting and, if necessary, by use of herbicide.

Summary of control measures

Table 4 summarises the recommended programme time frame and practices for control of problem plants on Otamahua. Table 5 lists plant species recently removed from the island. Steps have also been taken in 1998-2001 to kill adventive adults and many juveniles of most of the woody plants listed in Tables 1 and 4, wherever they were encountered.

Additional tasks related to control of problem plants

Linked with the ongoing initiatives for control of problem plants on Otamahua several other kinds of effort are required. One is a programme of mapping locations of all major pest plants, such as gorse, broom, boxthorn, hawthorn, flowering currant, elderberry, boneseed and big canary grass. A photo-map of the island, which incorporates a grid of 100 m interval is now available and will be very beneficial for this purpose. Also, a documentary record must be kept of the control measures, as they occur. This is essential for maintenance of continuity of the programme, especially with species that have long-term seed stores.

An education programme is needed to provide information to all who are participating in the weed control work. Part of the publicity will be a collection of dried plant specimens and photographs of target species, and an information dossier on locations, phenology, ecology and other features of the plants relevant to their control. Signage, pamphlets and posters may also be useful.

All Department of Conservation and scientific visitors to the island, as well as the general public, should be made aware of the risks of accidental introductions of unwanted plants and means to prevent them. Care is needed with soil in plant pots, or on tools, and seeds on clothing and footwear. Appropriate publicity is needed on these matters.

As was indicated by Burrows *et al.* (1999) some naturalized species are thought to have arrived on Otamahua by human agency (deliberate or accidental), while others (probably a smaller proportion) appear to have been transported there by natural vectors, including flotation in the sea and by aerial transport. Some introduced plants may also have been brought to the island by birds, but the evidence for this is limited to littoral or aquatic plants.

Additional non-indigenous species will probably reach Otamahua by natural or accidental means. As a matter of general policy a goal of the ecologists and managers responsible for care of the island should be to prevent the advent and increase there of such species as far as this is possible. It is not really possible to predict which species might ultimately gain access to the island. Detailed knowledge of the weedy foreign species of the local region (cf. Davis 1998; Wilson 1999) and general knowledge of their ecological behaviour in habitats similar to those of Otamahua enable us to be on guard against the worst of them. Among them are species which have already been removed (*Acer pseudoplatanus, Berberis glaucocarpa, Buddleja davidii, Ligustrum vulgare, Prunus avium, P. cerasifera, Arctotheca calendula, Dryopteris filix-mas*), as well as shrubby species listed in Table 1. Additional species to watch for include *Acaena agnipila* (sheep's burr)[A], *Berberis darwinii* (darwin's barberry)[B], *Carduus nutans* (nodding thistle)[W], *Carprobrotus* spp. (ice plants)[B], *Cotoneaster* spp. (cotoneaster)[B], *Hedera*

Table 2: Toxic plants on Otamahua / Quail island (Lists only species that remain on the island, or which may regrow from soil seed store).

	Poisonous parts	Symptoms of poisoning (includes symptoms in stock)	Potentially fatal	Abundance on the island (1998)	Action recommended
Native species					
Corynocarpus laevigatus P karaka	green or ripe fruit ? leaves	convulsions, paralysis	yes	two adults, few saplings	warning about toxicity
Myoporum laetum P ngaio	leaves, green stems	abdominal pain, facial swelling	yes	many adults, saplings	warning about toxicity
Solanum laciniatum P poro poro	green fruit	burning sensation in mouth	possibly	common	warning about toxicity
Sophora microphylla P kowhai	seeds, leaves, wood, nectar	vomiting, convulsions, paralysis, heartbeat irregularity	possibly	few adults and saplings	warning about toxicity
Urtica ferox P onga onga	stinging hairs on leaves, young stems	intense pain, numbness, loss of co-ordination	yes	moderately common	warning about toxicity
Introduced species					
Conium maculatum B hemlock	leaves, stems, seeds, roots	excessive saliva, body pain, convulsions, paralysis	yes	locally common	complete eradication
Digitalis purpurea B foxglove	leaves, stems, seeds	vomiting, diarrhoea, slow pulse	yes	local, uncommon	complete eradication
Laburnum anagyroides P golden rain	flowers, leaves, green pods, seeds, wood, bark	vomiting, convulsions, paralysis, heartbeat irregularity	yes	one tree at Visitor Centre/seedlings	remove the tree and seedlings
Quercus robur P european oak	acorns	loss of appetite, constipation	yes	common, but local	warning about toxicity
Silybum marianum B variegated thistle	leaves	drowsiness, staggering, diarrhoea	yes	common	progressive removal (initially remove main infestations)
Solanum dulcumara P bittersweet	leaves, stems, fruit	headache, nausea, gastritis, paralysis	possibly	local, uncommon	complete eradication
Urtica urens A - P nettle	stinging hairs on leaves, stems	pain in the affected parts	no	local, moderately common	attempt to eradicate

Ref. Connor (1992). P perennial; B biennial; A annual

Table 3: Nuisance plants of Otamahua/Quail island

	Nuisance property	Abundance on the island (1998)	Action recommended
Native species			
Acaena novae-zelandiae bidibidi	ripe fruit adhere to clothing	common	nil
Discaria toumatou matagouri	spiny stems	locally common	nil
Introduced species			
Bromus spp. (and possibly other grasses) brome grass	ripe fruit adhere to socks, footgear	locally common	suppress with planted woodland
Berberis glaucocarpa barberry	spiny stems	one plant known	see Table 5
Crataegus monogyna hawthorn	spiny stems	scattered plants	see Table 1
Carduus tenuiflorus winged thistle	prickles	widespread	see Table 1
Cirsium arvense california thistle	prickles	widespread	see Table 1
C. vulgare scots thistle	prickles	widespread	see Table 1
Lycium ferocissimum boxthorn	spiny stems	scattered plants	see Table 1
Rosa rubiginosa brier rose	thorny stems	scattered plants	see Table 1
Silybum marianum variegated thistle	prickles	locally common	see Table 1
Ulex europaeus gorse	spiny stems	scattered plants	see Table 1
Urtica urens nettle	stinging hairs	local	kill out if possible

Table 4 Summary programme for control of problem plants on Otamahua/Quail Island

Control by 1. Trust; 2. Department of Conservation; 3. Special work parties, including volunteers; 4.Contractors

A	**On areas to be planted in indigenous woodland**			
		First year	**Second year and possibly later**	**Within 3-5 years**
i)	Pasture grasses 1	Kill on local areas with herbicide, and mulch, where necessary.	Follow-up, if necessary with grass-specific herbicide.	Aim for rapid growth of canopy of woodland species to suppress the herbs.
ii)	Some other perennial rhizomatous or biennial weedy dicotyledon herbs 1	Kill with herbicide, or in some cases hand-pull, and mulch, where necessary.	Cut re-growth or spray with herbicide. Judicious painting with herbicide or use of biocontrol may be possible for some.	
iii)	Gorse, broom 1, 2, 3, 4	On areas to be planted with native woody species within two years control the weeds with non-residual herbicide.		
iv)	Other woody plants (juveniles of introduced trees; adults or juveniles of weedy shrubs) 1, 3	Hand-pull, grub or cut and paint with herbicide all plants in a 250 m radius of each planting area. Carry out annual checks to clear problem plants from these areas.		
v)	Adult planted trees 1, 2, 3, 4	Remove any that obstruct the planting operations. In some cases kill the trees by ring-barking, and later fell them.		
B	**On the whole island**			
i)	In 2001 spray all broom and gorse plants with residual herbicide to kill adults and emerging seedlings. Continue this periodically. See note A iii) above 2,4. Hand-pull or kill juveniles with herbicide on sites soon to be planted. Follow-up by killing (pulling, grubbing, herbicide) isolated plants that appear. In areas with stores of dormant seeds either encourage dense grass growth, or densely plant with kanuka. Monitor the sites annually. Similar treatment will be accorded to biennial and perennial herbaceous problem plants: winged, california and variegated thistles, where control is desirable. Avoid soil disturbance as much as possible. Biocontrol methods could be used, where feasible. 1, 2			
ii)	In 2001 aim to kill all remaining adults of fleshy fruited problem woody plants (except boneseed, boxthorn). Over the period 2001-2002, attempt to remove all juveniles by hand pulling, grubbing, spraying. Monitor at one or two year intervals thereafter. 1, 3			
iii)	In 2001-2002 continue the process of systematic removal of all relatively accessible boneseed and boxthorn. Concentrate on adults (cut, herbicide), but boneseed juveniles can flower and seed in their first year so herbicide treatment, or hand pulling of them is desirable. Cliff face habitats must be cleared, eventually. Aim to remove all adults of these two species from the cliffs by 2003. 1, 3			
iv)	In 2001-2002 near planting areas kill all remaining young wilding pines, cypresses, birches, ashes, holm oaks, european oaks, bluegums and any silver poplar, young or old; totally remove cherry, grey willow, holly (cutting, grubbing, herbicide). Monitor for regrowth at one or two year intervals. 1, 2			
v)	In 2001-2002 remove all prickly lettuce, hemlock and foxglove regrowth by hand pulling, grubbing, herbicide. Monitor and kill each year thereafter. 1, 3			
vi)	In 2001-2002 begin a programme of eradication of *Phalaris* using herbicide. 1, 2			

Table 5 Plant species which have been removed on Otamahua/Quail Island during 1998 - 2000

Taxon	Known population, location
Argyranthemum frutescens marguerite	two plants, Ski-lane beach; E. of Visitor Centre
*Berberis glaucocarpa** barberry	one plant, track up from jetty
*Buddleia davidii** butterfly bush	one plant near 1998 main planting area
Calendula officinalis marigold	six plants, Ski-lane beach
Clematis vitalba+ old man's beard	ten plants, W. of 1998 main planting area; E. of Visitor Centre; Stables; above Leper level
Conium maculatum+ hemlock	c. 150 plants, sewage treatment area; near stockyard; E. of Visitor Centre; top of big oakwood; W. of Leper level
Conyza albida+ fleabane	c. 35 plants, Ward's Beach; S.; Visitor Centre; E. of Cottage
C. bonariensis + fleabane	two plants, Visitor Centre
C. bilbaoana+ fleabane	two plants, slopes near Ship's Graveyard
Drosanthemum floribundum small ice plant	one plant, N.E. Point
Dryopteris filix-mas+ male fern	c. 5 plants, clifftop W. of Ward's Beach; S. and E. of Visitor Centre; Implement Shed; near Stables; slip above Ski-lane beach; above Leper level; oak wood
Hieracium pilosella+ mouse ear hawkweed	one patch, cliff near Walker's Beach
Hirschfeldia incana+ hoary mustard	four plants, Walker's Beach; E. of cottage
*Iris foetidissima** stinking iris	one plant,Visitor Centre
Lactuca serriola prickly lettuce	c. 40 plants, Stables; E. of Cottage; 1998 main planting area; above Walker's Beach
*Ligustrum vulgare** privet	two plants, track up from jetty
Linaria purpurea+ purple linaria	one plant, 1998 main planting area
Lupinus arboreus yellow lupin	18 plants, sewage effluent area
Osteospermum fruticosum dimorphotheca	one plant, Ski-lane beach
Picris echioides+ oxtongue	c. 20 plants, Walker's Beach
Prunus cerasifera plum	nine plants, track up from jetty (open paddock); Swimmer's Beach lower slopes; Barracks
*Salix cinerea**+ grey willow	c. 15 plants, near Barracks; slip above Ski-lane beach
Solanum physalifolium+ hairy nightshade	one plant, Ballast Quarry Beach
Tripleurospermum inodorum+ scentless mayweed	six plants, Walker's Beach; Visitor Centre

* apparently deliberately planted
Checks need to be made in future in case of regrowth of the shrubs and vines (and any herbs marked+)

helix (ivy)[B], *Hieracium praealtum* (king devil hawkweed)[W], and other *Hieracium* spp.[W], *Leycesteria formosa* (himalaya honeysuckle)[B], *Lonicera japonica* (honeysuckle vine)[B], *Nassella trichotoma* (nassella tussock)[A], *Rubus fruticosus* (blackberry)[B], *Spartina anglica* (cord grass)[F], *Stipa* spp. (needle grass)[A], *Tradescantia fluminensis* (wandering willy)[A] ([W] = diaspores wind dispersed, [B] = bird-dispersed, [F] = dispersed by flotation, [A] = accidentally-dispersed, by people).

Guarding against natural or accidental introductions of plant pests will require a quite stringent set of protocols, as outlined earlier. It will also entail continual vigilance, the sharp eyes of experienced botanists and the will to carry out control measures. The island is small enough for the programme outlined in Table 4 to be a realistic aim for problem plants already on the island, as demonstrated by the results of the control programme to date. The goals noted in Table 4 can be extended to any new plants which could create problems.

Conclusion

Like the rest of New Zealand, Otamahua/Quail Island has a dual flora: indigenous and introduced. This is something we must learn to live with because only rarely can the introduced plants be eliminated, except on local areas. In any case, for a variety of reasons many species of introduced plant are to be fostered on the island. The fortunate position on Otamahua is that many of the woody and some herbaceous problem plants can, with determination, be completely removed. Furthermore, the isolation of the island makes it unlikely that invasion by other pest plants could create major difficulties for the proposed ecological restoration.

The ultimate responsibility for control of problem plants on Otamahua rests with the Department of Conservation. The Department's management staff in Christchurch has resolved that, in co-operation with the Otamahua/Quail Island Ecological Restoration Trust, and with the help of a workforce of volunteers, and some waged workers, the problem plants of the island will be dealt with, in much the same way as was the rabbit pest problem (Genet & Burrows 1999).

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Appendix 1. Additions to the Flora and Other Notes

Flora

The known vascular plant flora for the island now numbers 375 (cf. Burrows *et al.* 1999, see main reference list). Additions to the indigenous flora are a natural *Coprosma* hybrid; a grass often present in open woodland; and two self-introduced ferns, rare on western Banks Peninsula. The other additions include a record for a peach tree, removed in the 1980s (J.W.); some planted or garden escape bulbous perennials; some annual herbaceous weedy species which grew on sites disturbed in 1999 by tree-planting (thus activating soil-stored seeds); a tomato plant below the north eastern cliffs, which presumably grew from a seed from a discarded fruit of this species; a large succulent, common on Banks Peninsula cliffs and several other plants, seen so far only on the talus slopes beneath the cliffs; a perennial weed of pastures for which this is apparently the first South Island record (*Oenanthe*); and a root parasite herb.

Seedlings of planted indigenous woody species

The definitive floristic list for the island published in Burrows *et al.* (1999) included data on observations of seedlings derived from indigenous trees planted in the 1980s. Seedlings of three more of these species were seen over the summer-autumn of 1999-2000 (*Aristotelia serrata, Kunzea ericoides,* and *Pseudopanax arboreus*). This brings the number of species in this category to 13, out of a total of 15. The only tree species for which seedlings have not yet been seen are *Griselinia littoralis* and *Podocarpus totara.*

The moist spring of 1999, after a moderate seeding in late summer – winter of 1998, and the absence of rabbits, saw the appearance on bare ground in various places on the eastern half of the island of numerous seedlings of *Coprosma robusta, Cordyline australis, Pittosporum eugenioides, P. tenuifolium, Myoporum laetum* and *Myrsine australis* (as well as the true indigenes *Coprosma propinqua, Melicytus ramiflorus, Olearia paniculata* and *Solanum laciniatum*).

The crops of seedlings and growth of self-sown small saplings of most of the commoner indigenous species indicates that natural regeneration of many of the recently planted taxa (cf. Burrows *et al.* 1999) is likely. Saplings of self-sown *Coprosma crassifolia, C. propinqua, C. robusta, Kunzea ericoides, Melicytus ramiflorus, Myrsine australis, Olearia paniculata, Pittosporum eugenioides, Solanum laciniatum,* and many young plants of *Phormium tenax,* came through the severe drought of the summer 1998-99 (as did about 95% of the 1500 trees and shrubs planted in 1998) (Burrows *et al.* 1999). These observations indicate, clearly, that the ecological restoration plantings will succeed and that the native woodland that is being planted will, in due course, be self-sustaining.

Myoporum laetum seedlings have been observed during 1999-2000, in many places on the eastern third of Otamahua. During the summer 1998-99 *M. laetum* flowered well and bore many fruit, so most of the seeds that germinated probably originated then. Seedlings emerged in the autumn of 1999 and again in the spring of that year and over the summer 1999-2000. Seedlings have been found as far as 200 m from the nearest adults that fruited in 1998-99, including a few on talus beneath the northern cliffs.

An intriguing occurrence in spring 1999, on the site of a large fire of branches and other combustible debris, which was lit in the winter of 1999, was the growth of many *M. laetum* seedlings. The seeds must have been deposited before the fire and not harmed by it. Their germination may have been stimulated by it. Some *Myoporum* seedlings grew more than 80 cm tall on this site in summer-autumn 1999-2000. *Solanum laciniatum* on the same site grew more than 2 m tall in the one growing season.

Another interesting discovery (made in autumn 2000 by J.W.) was of two *Corynocarpus laevigatus* seedlings, probably only two or, at most, three years old and 10-12 cm high, about 100 m from the parent trees. They grew part way underneath large, old conifer logs, in a site among young *Cupressus macrocarpa* trees which have since been felled. The seeds must have been carried to the site by an animal vector. The most likely such vector could have been human, or rabbit. The seedling locations under the edges of logs favour the latter. A rabbit skeleton was found beside one of the seedlings.

Other plant records

In the floristic list for Otamahua of Burrows *et al.* (1999) distribution and habitat records were given for the taxa. Further locations have been found for numbers of the taxa, but the only ones mentioned here are for some unwanted plants for which attempts at eradication are being made. All plants seen of each species have been removed.

Clematis vitalba One large plant with stems of maximum length of about 3 m and perhaps as much as five years old was present in 1998 near the Stables. It appeared never to have flowered. All other plants found, scattered on the eastern and southern aspects of the island were much smaller and probably only about one to three years old. It is assumed that all of these plants were recent colonists, dispersed aerially from the mainland.

Conium maculatum Two sizeable colonies occurred, one west of the Stables, the other on the sewage treatment area. Two further small colonies have been found, one at the oak wood northern margin, near the junction of middle and Cross Tracks, the other under conifers west of the Leper Hospital site.

Dryopteris filix-max A large plant was found above the northern cliffs in an old rabbit burrow area. All other plants, found in widely scattered places on the south side and eastern end of the island, were much smaller and probably very recent colonists. The spores of this species probably rain down abundantly on the island, derived from locations on the mainland to W, N and NE.

Lactuca serriola An extensive colony grew up near the Stables in 1999. Individuals only were seen in the open field on the slope above the Barracks, and on the slope above Walkers Beach. Each site had been considerably disturbed; it is uncertain whether the species is a recent, aerial, arrival on the island, or has been present in a seed bank, with activation of germination because of the

Additions to the Vascular Plant Flora of Otamahua/Quail Island 1999-2001.

Key: O, originally present; P, planted in the 1980s or earlier; N, naturalised on Otamahua. (R), immigrated naturally, recently; X, removed from the flora between 1976 and 1998; L, lost or removed recently; *, first record for the South Island. Location - general position on the island. Habitats are indicated only for naturalised species or indigenous species. Abundance, few-only a few tens observed. Record, 3 -observed during recent fieldwork or (*Prunus persicaria*) a personal communication.

	Family	O	P	Location	Specific Habitat	Abundance	Record
A. Indigenous Species							
Shrubs							
Coprosma robusta x *C. propinqua* hybrid	Rubiac.	•(R)		E	under conifers	one	3
Herbs							
Monocotyledons							
Microlaena stipoides	Poac.	•		S	under deciduous oaks	few	3
Ferns							
Histiopteris incisa mata	Dennst.	•(R)		S	conifer stump	one	3
Paesia scaberula scented f.	Dennst.	•(R)		E	conifer stump	one	3

	Family	P	N	Location	Specific Habitat	Abundance	Record
B. Introduced Species							
Trees							
Prunus persicaria blackboy peach	Ros.	•X		E		one	3
Racosperma cf. *decurrens* green wattle	Mimosac.		•(R)L	NE	scree beneath cliff, near sea level	five (juvenile)	
Herbs							
Grasses							
Lolium multiflorum Italian ryegrass	Poac.		•	NE	scree beneath cliff	few	3
Other monocotyledons							
Allium triquetrum three-cornered garlic	Alliac.	•	•	E	under conifers	few	3
Leucojum aestivum snowflake	Amaryll.	•		S	leper grave	few	3
Dicotyledons							
Consolida ambigua larkspur	Ranunc.		•	E	bare, disturbed area	one	3
Conyza bonariensis fleabane	Aster.		•L	E	bare, disturbed area	few	3
Cotyledon orbiculata elephant's ears	Crassul.		•	N	beneath cliffs	few	3
Epilobium ciliatum tall willow herb	Onagr.		•	E	bare, disturbed area	few	3
Euphorbia peplus milkweed	Euphorb.		•	E	bare, disturbed area	few	3
Lycopersicon esculentum tomato	Solan.		•	N	scree beneath cliffs	one	3
Malva nicaeensis French mallow	Malv.		•L	NE	scree beneath cliffs	few	3
Oenanthe pimpinelloides parsley dropwort	Apiac.		•L*	E	grassland	few	3
Orobanche minor broomrape	Orobanch.		•	E	grassland under trees	few	3
Parentucellia viscosa tarweed	Scroph.		•	E	disturbed area	one	3

disturbance.

Opuntia cylindrica The species was recorded in Burrows *et al.* (1999) as having died out. However a few individuals were found recently below the northeastern cliffs (and have been removed).